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H275

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UK CL (Edition P) F4A ADD AHA AJH, H5H HBG1
HBG2 HBG3

INT CL⁶ F24H 1/10 1/12 1/14 1/16, H05B 3/26 3/30
3/82

OPTICS

(54) Abstract Title

Printed circuit instantaneous electric water heaters

(57) An instantaneous electric water heater 1 has a heating element 7 in the form of a resistive and conductive track printed on a metal plate 3 for conducting heat produced by passing an electric current through the track to water flowing through the heater 1. The heating element 7 is aligned with a serpentine waterway 6 rising from an inlet 11 to an outlet 12 and a closed loop control system is operable to regulate power input (Figure 5) or water flow (Figure 6) in response to the outlet water temperature sensed by a printed temperature sensor 16 on plate 3 to maintain substantially constant a selected water temperature. Various arrangements of element/waterway are disclosed (Figures 7 to 20).

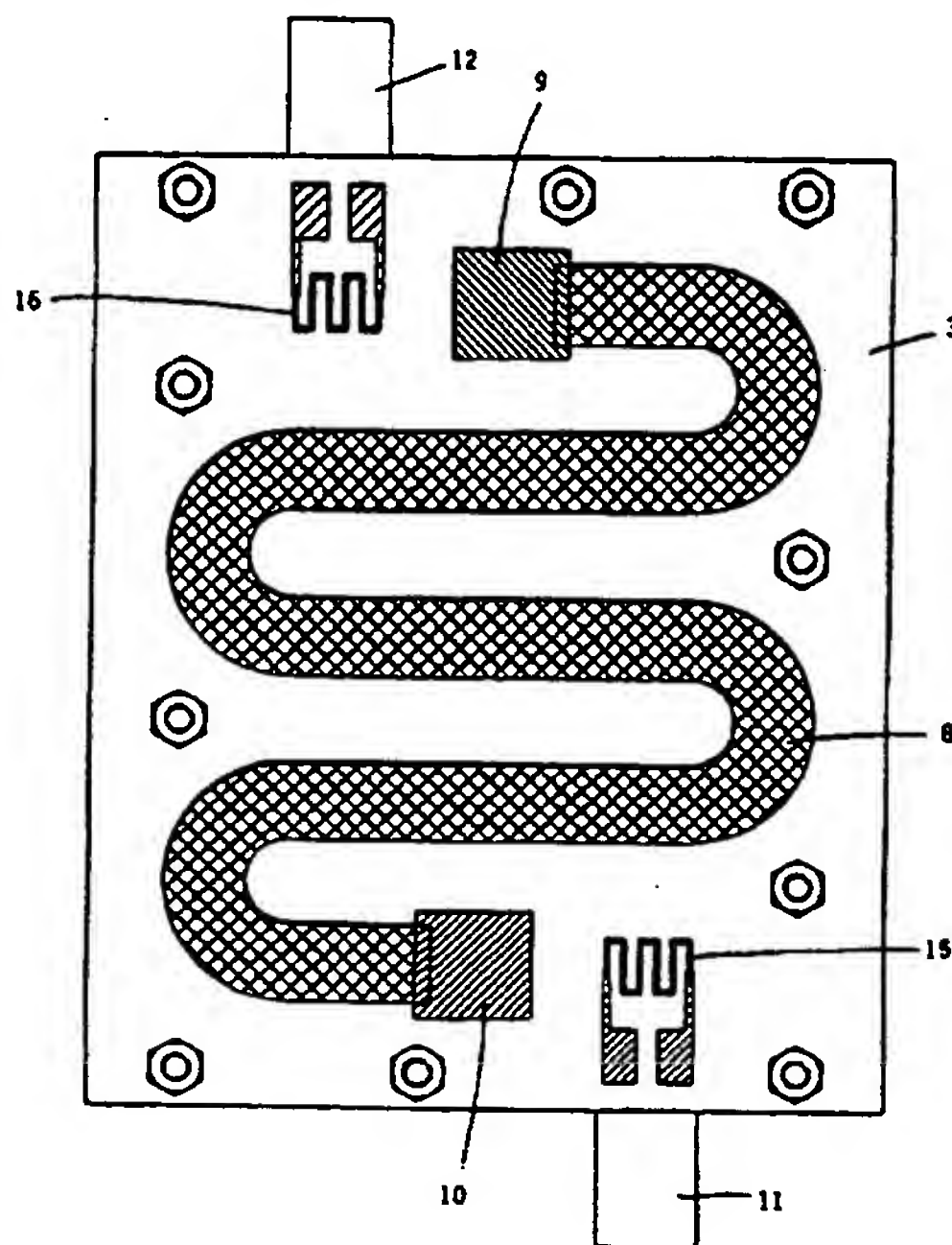


FIGURE 2.

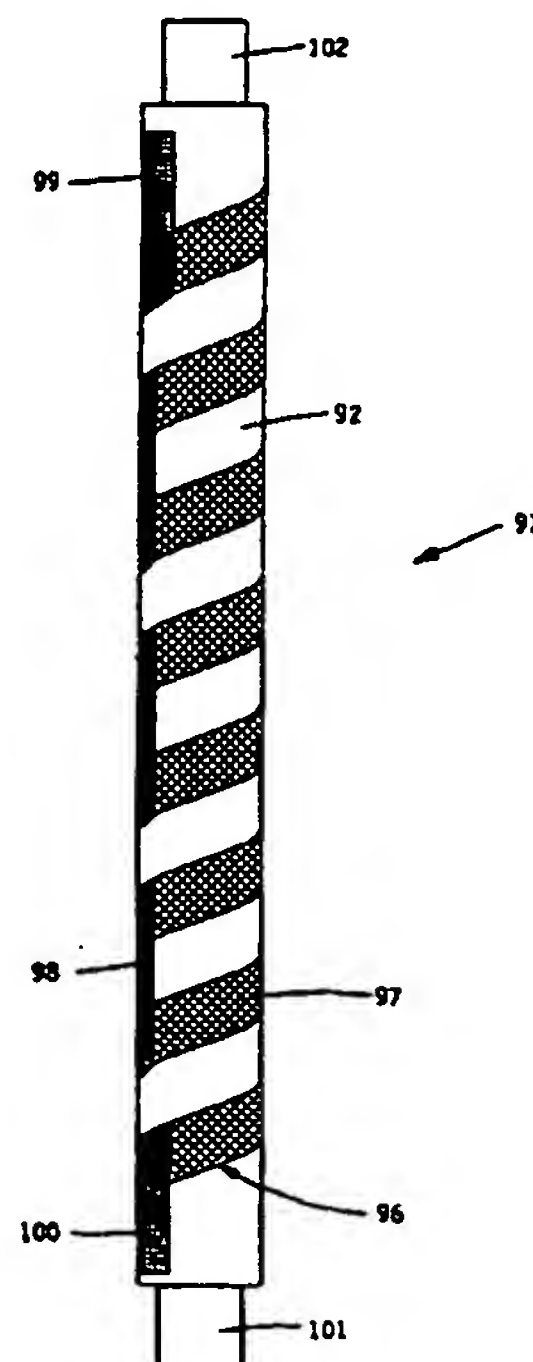


FIGURE 14.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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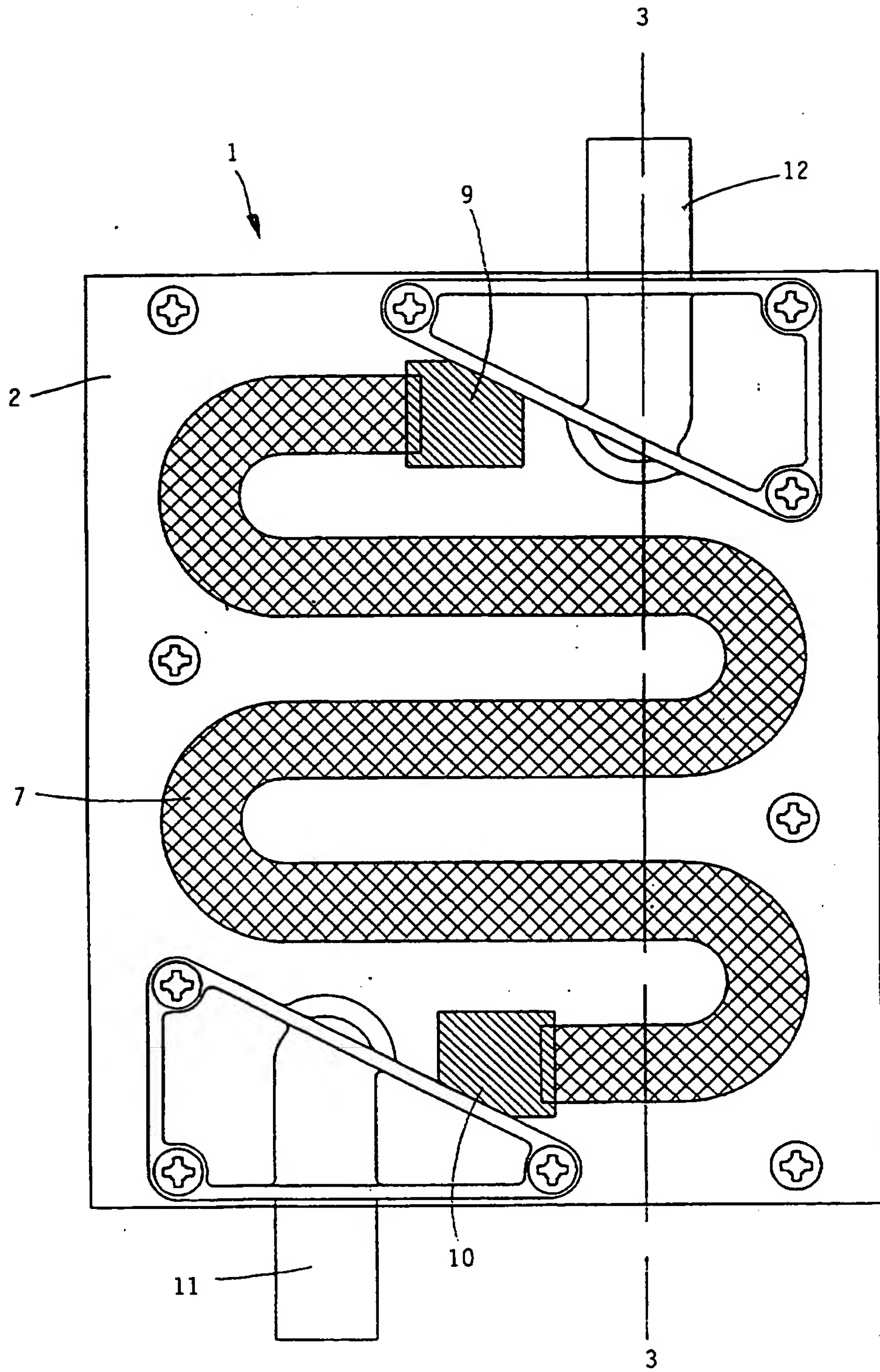


FIGURE 1.

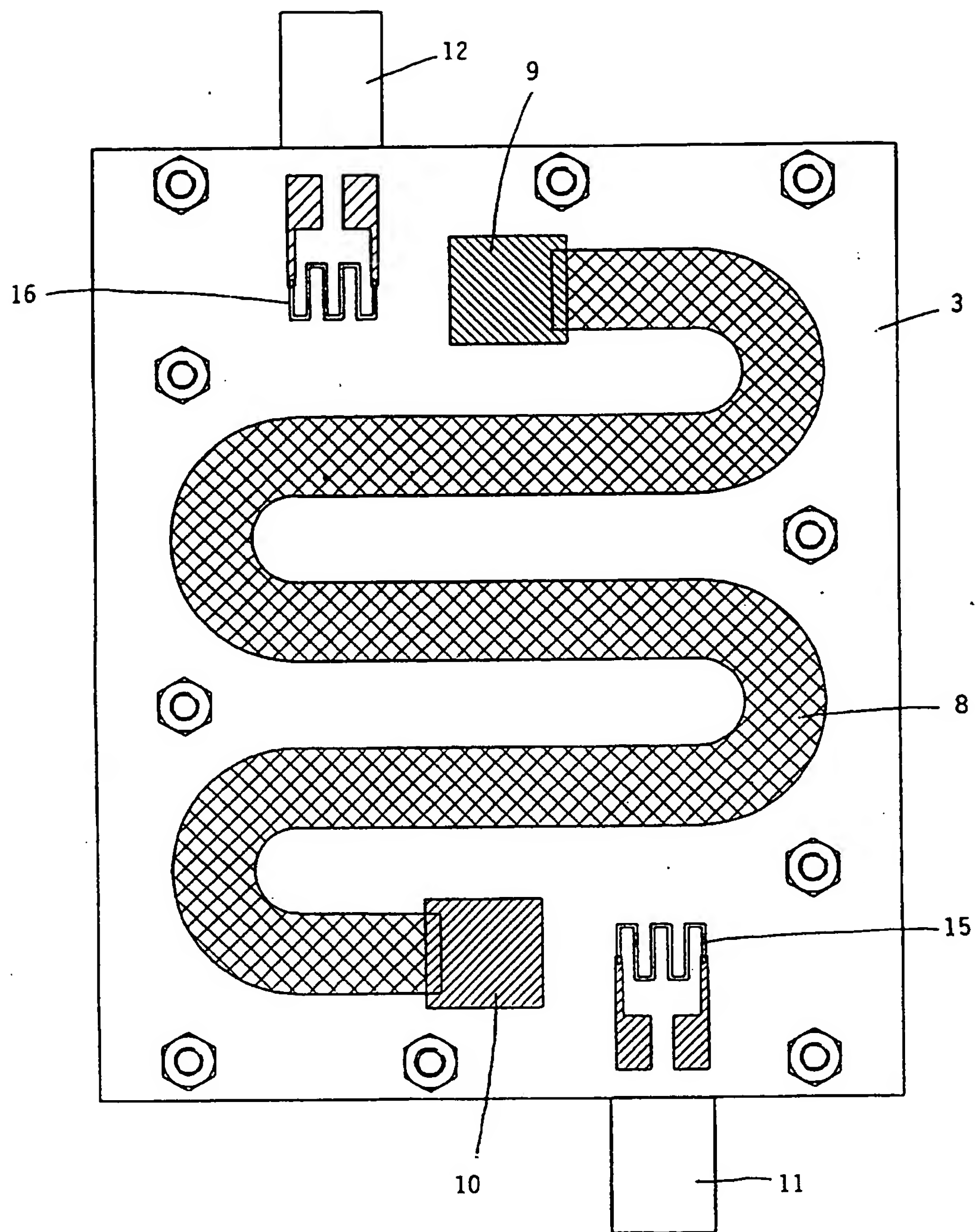


FIGURE 2.

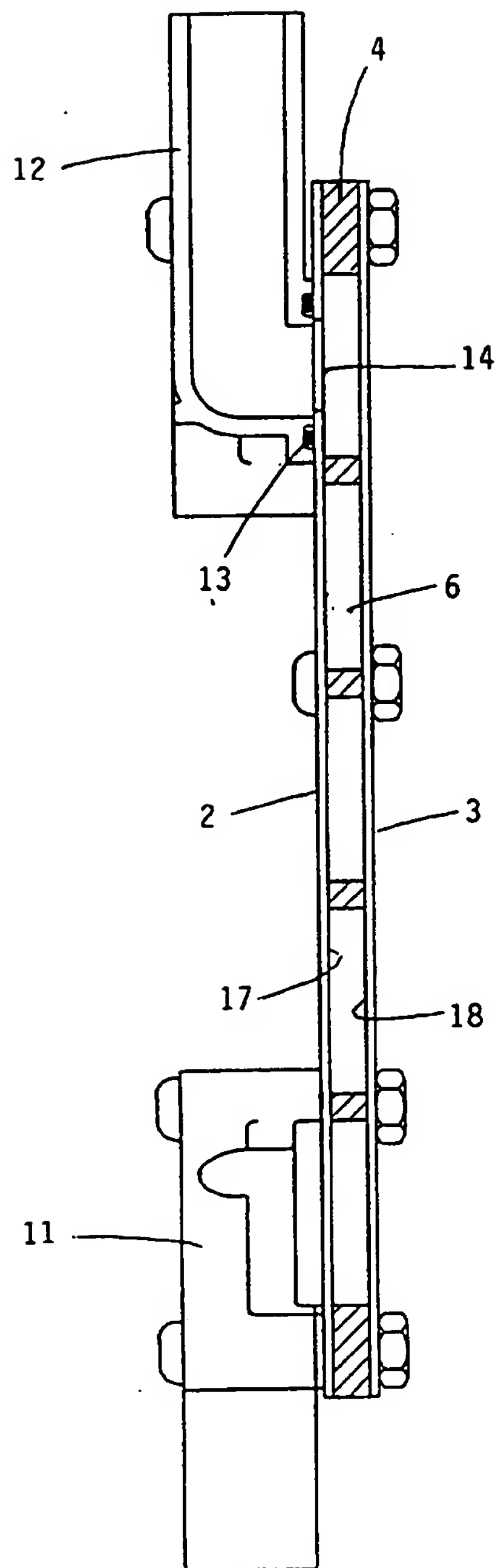


FIGURE 3.

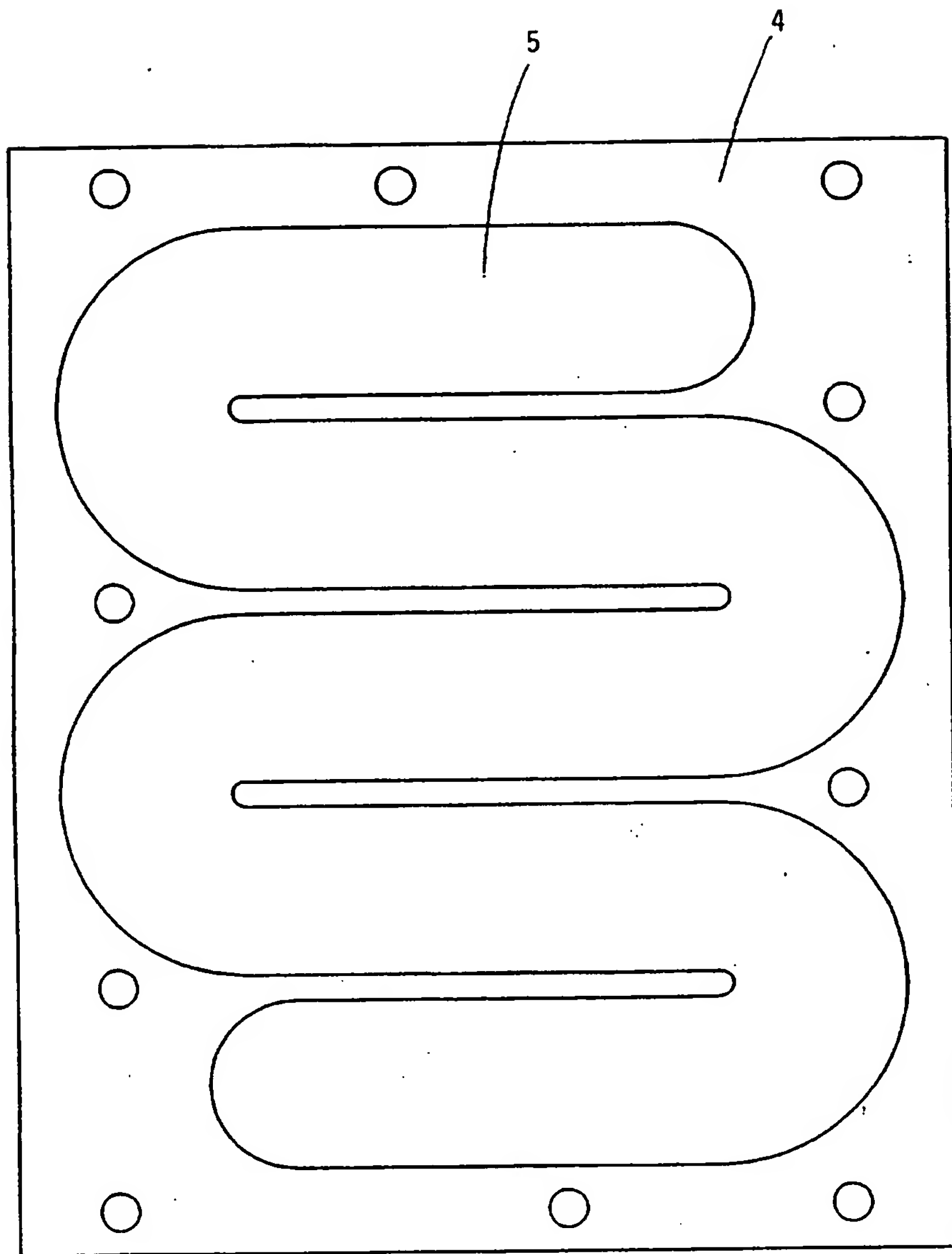


FIGURE 4.

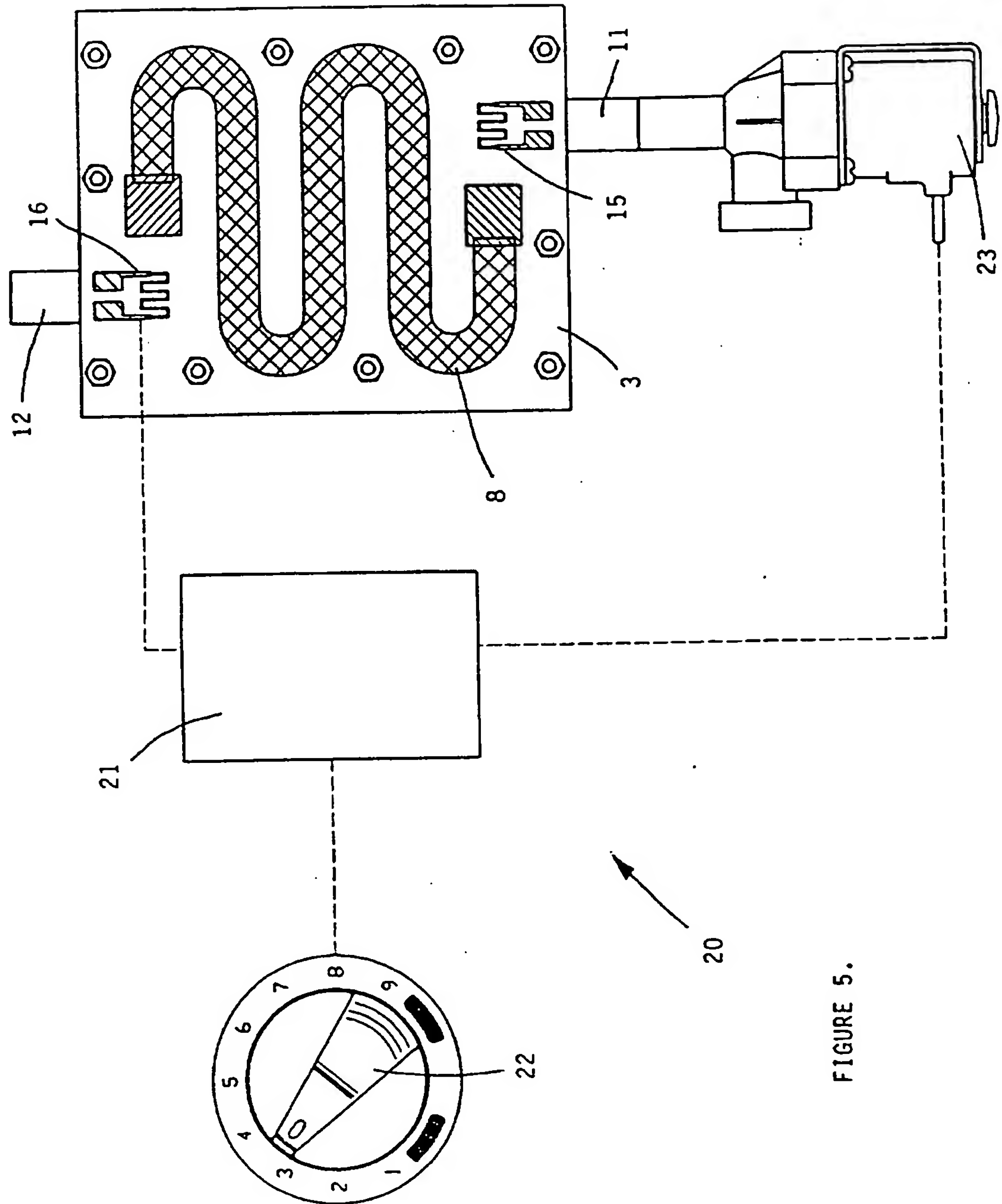


FIGURE 5.

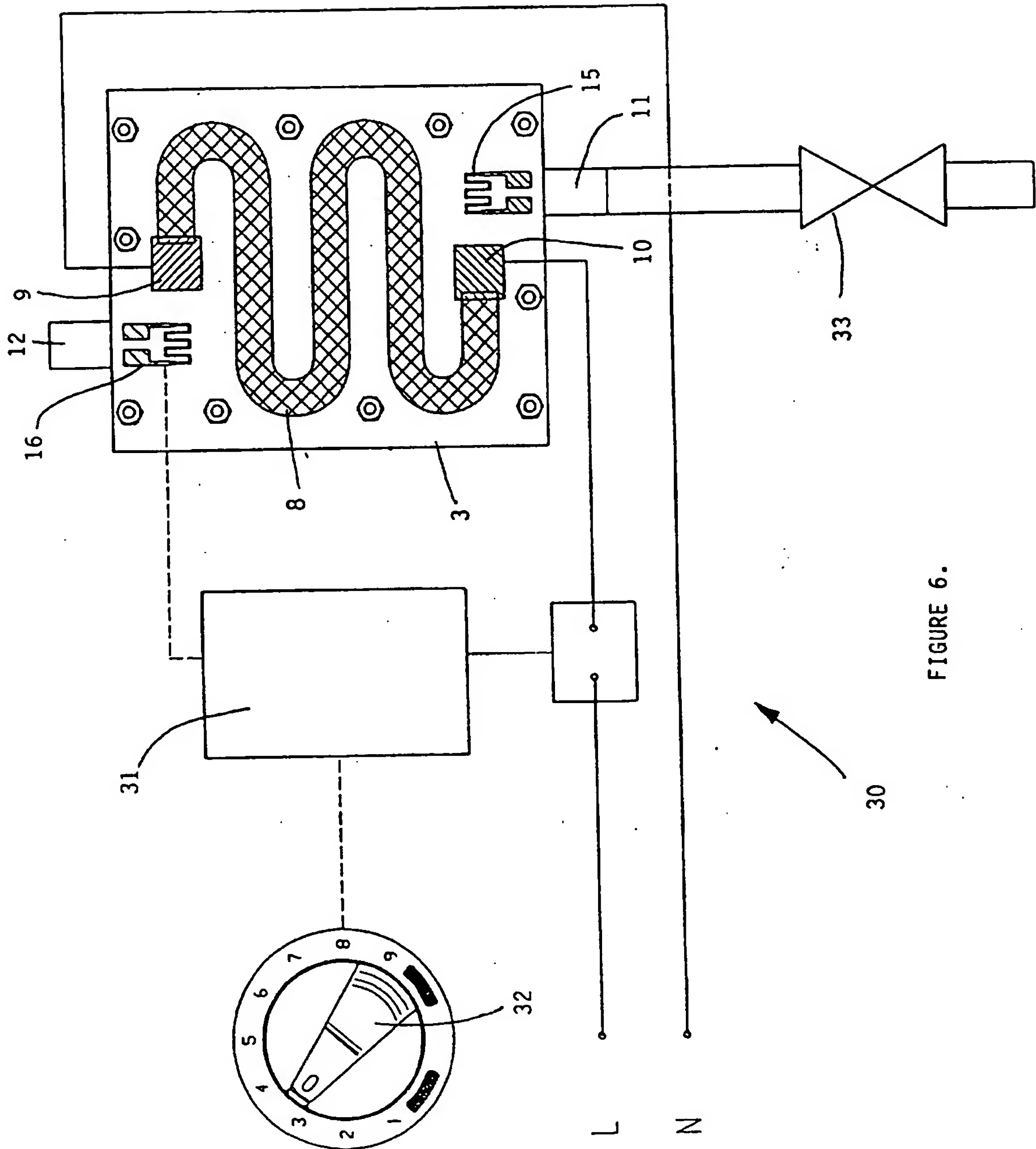


FIGURE 6.

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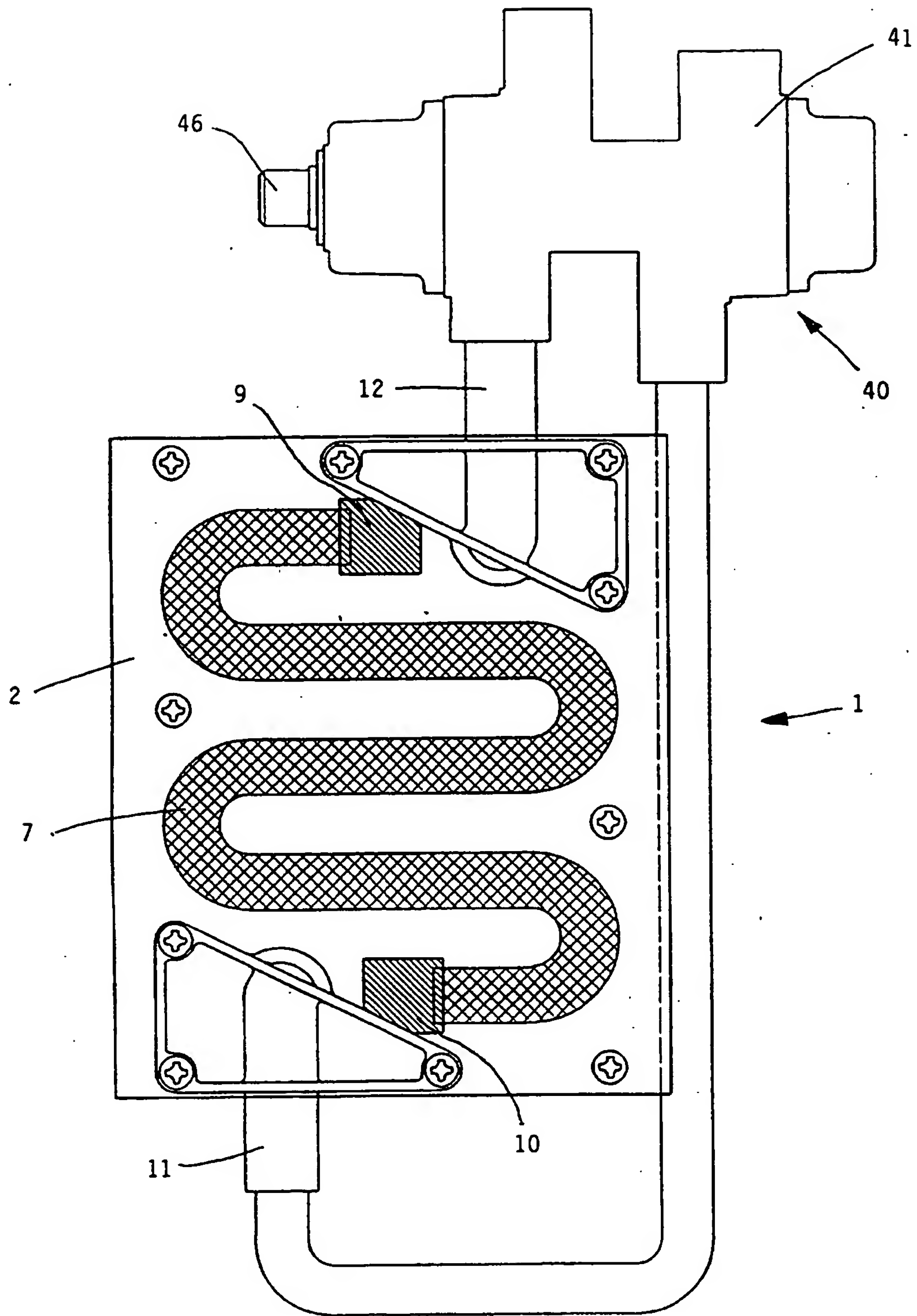


FIGURE 7.

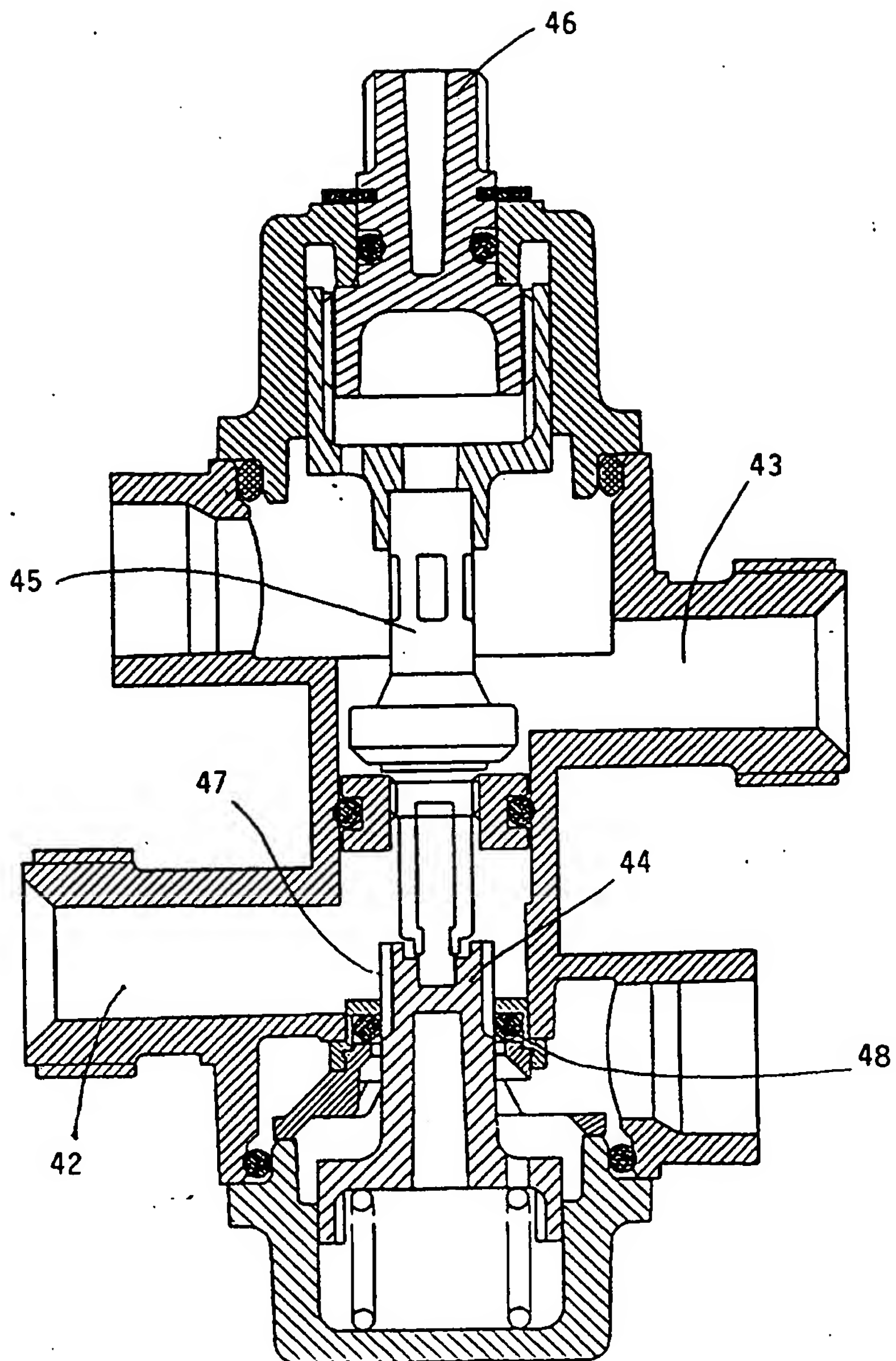


FIGURE 8.

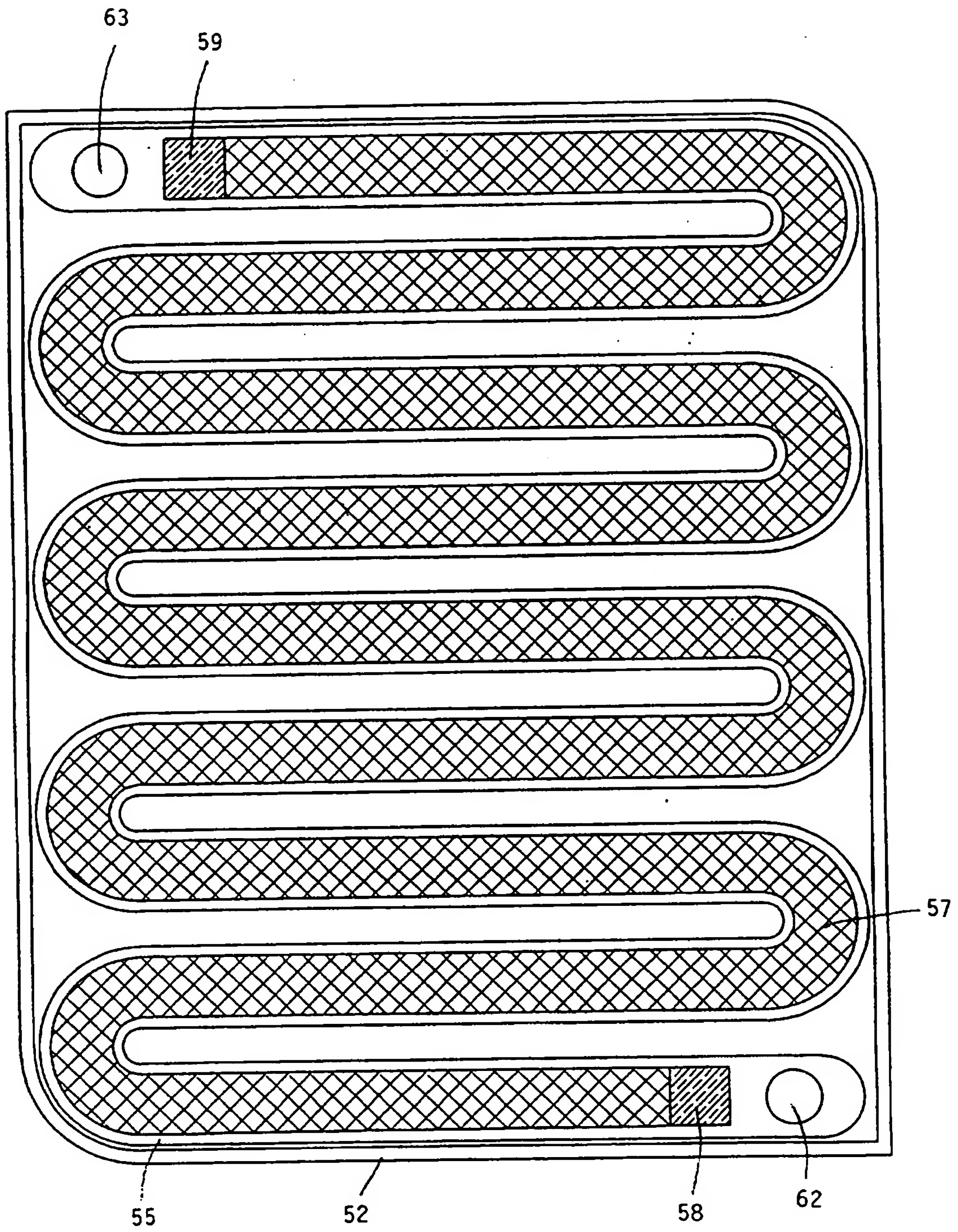


FIGURE 9.

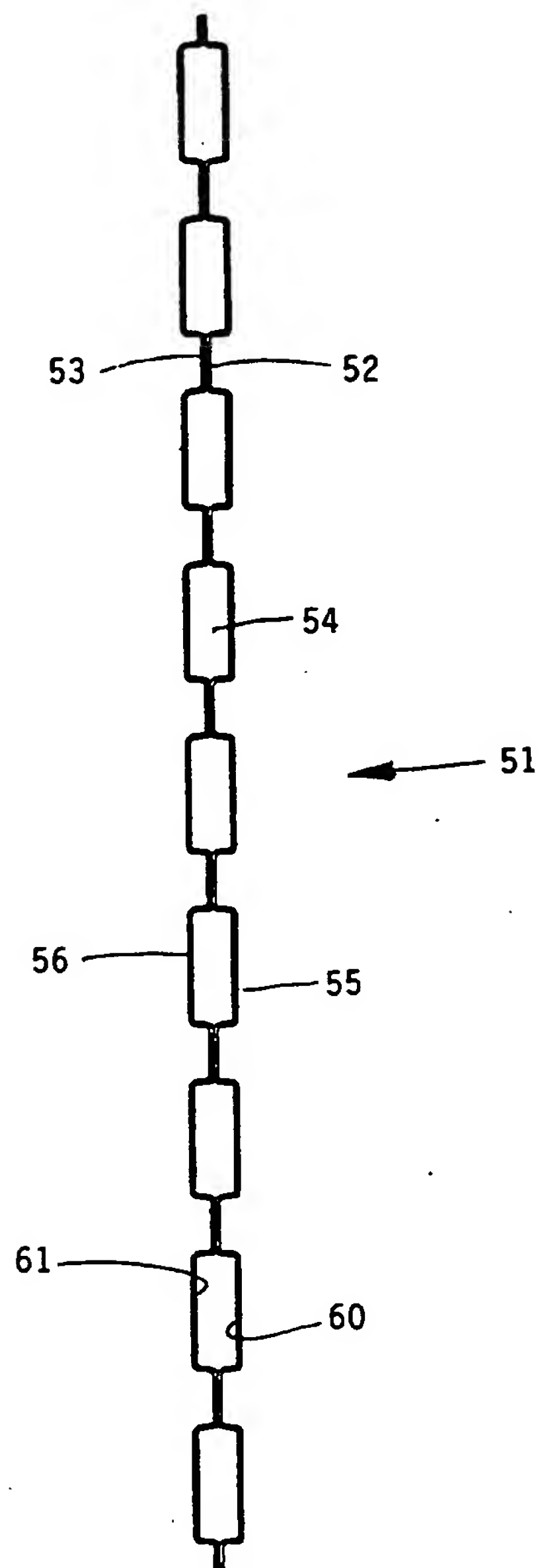


FIGURE 10.

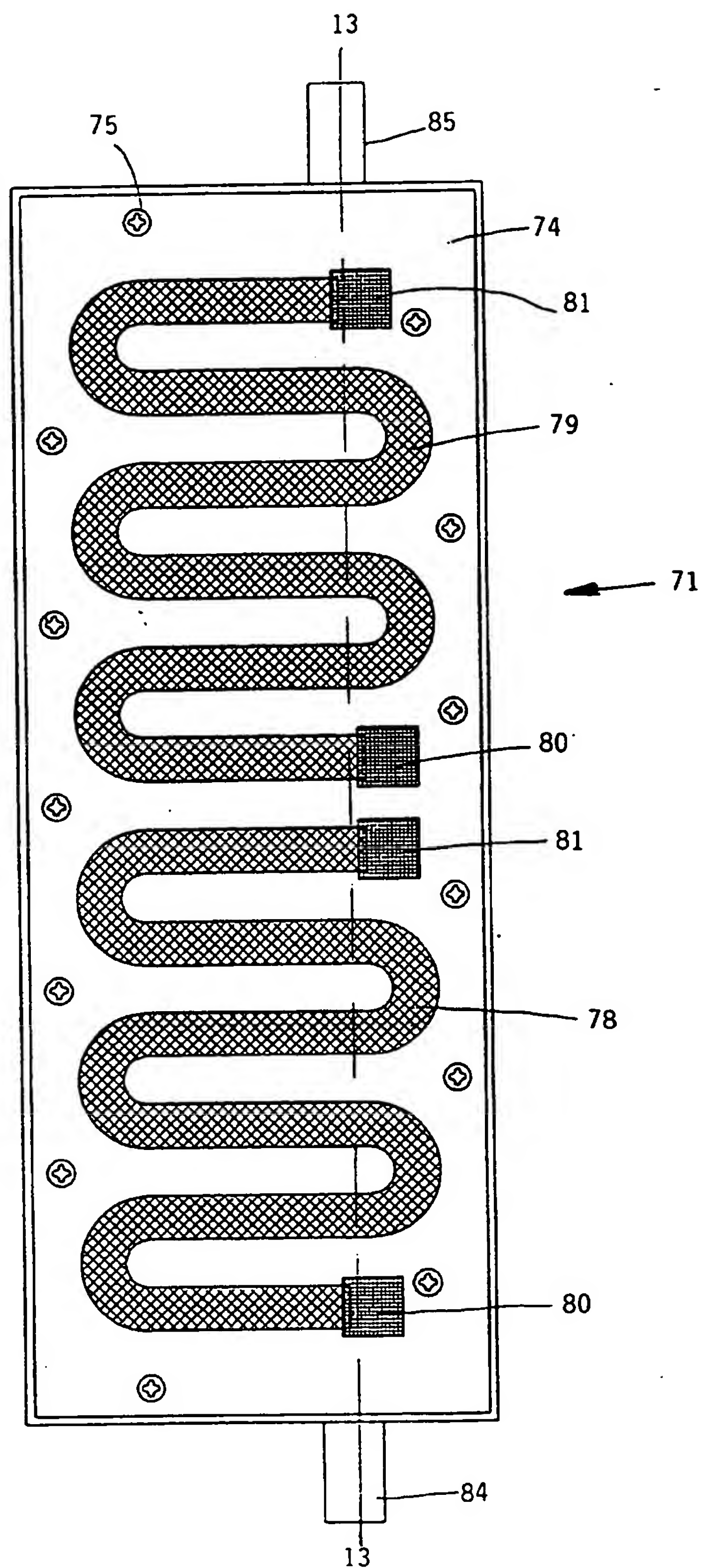


FIGURE 11.

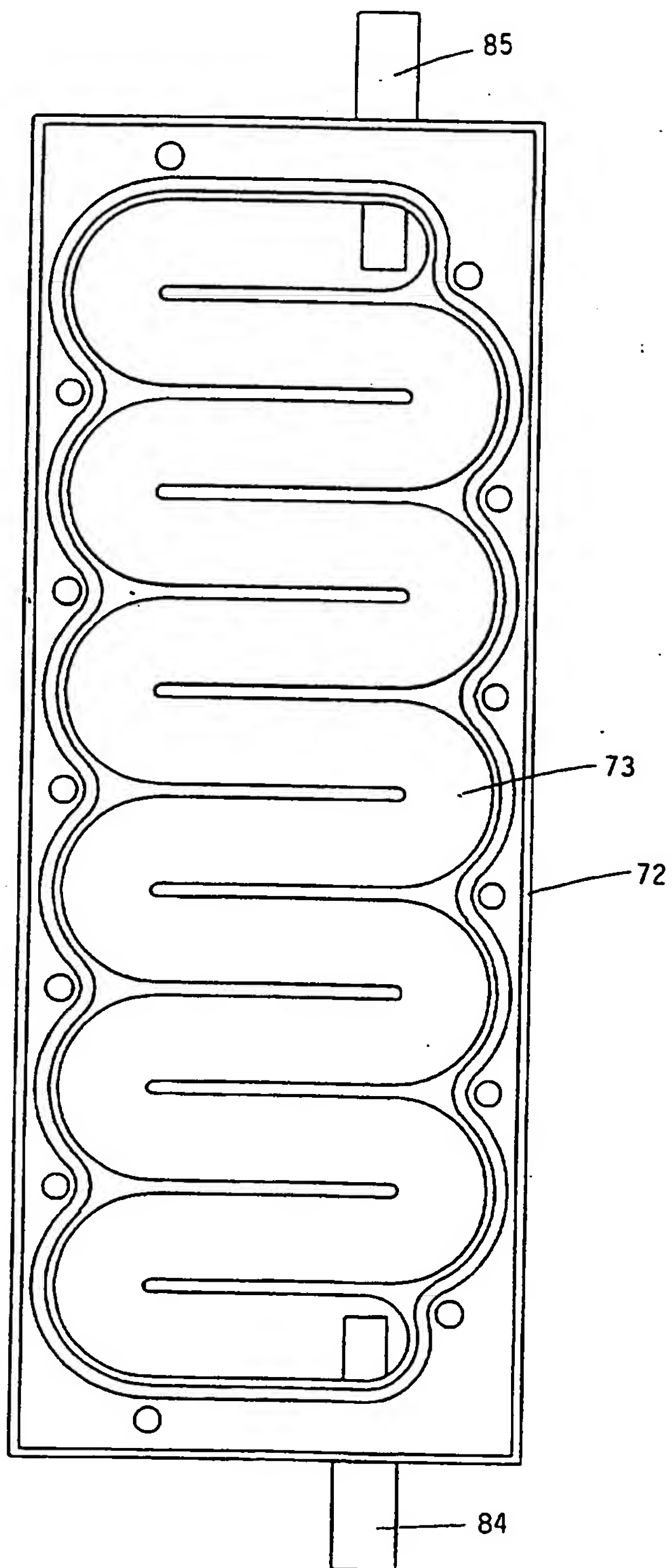


FIGURE 12.

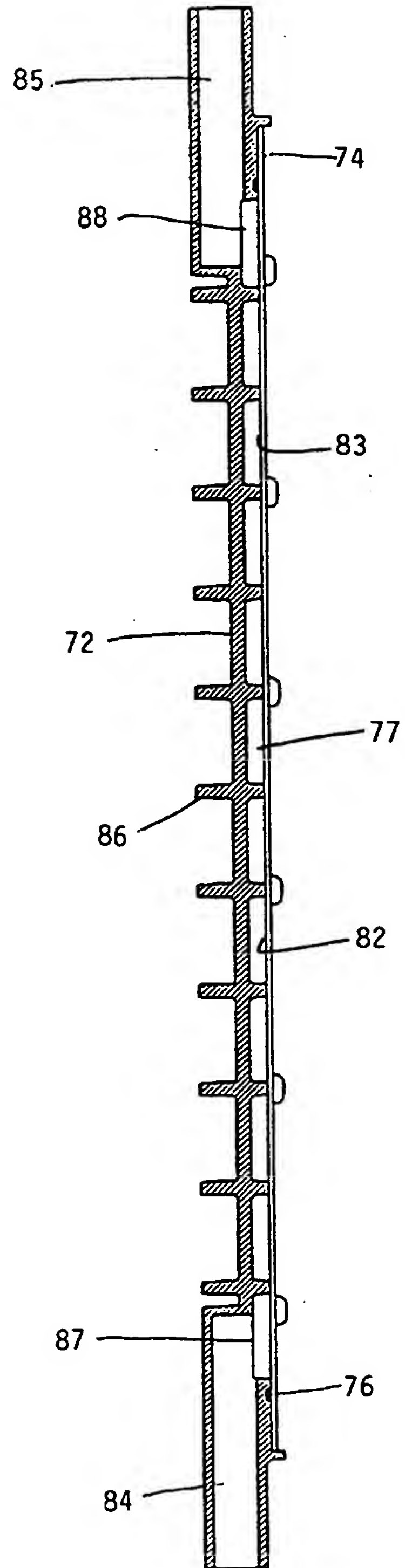


FIGURE 13.

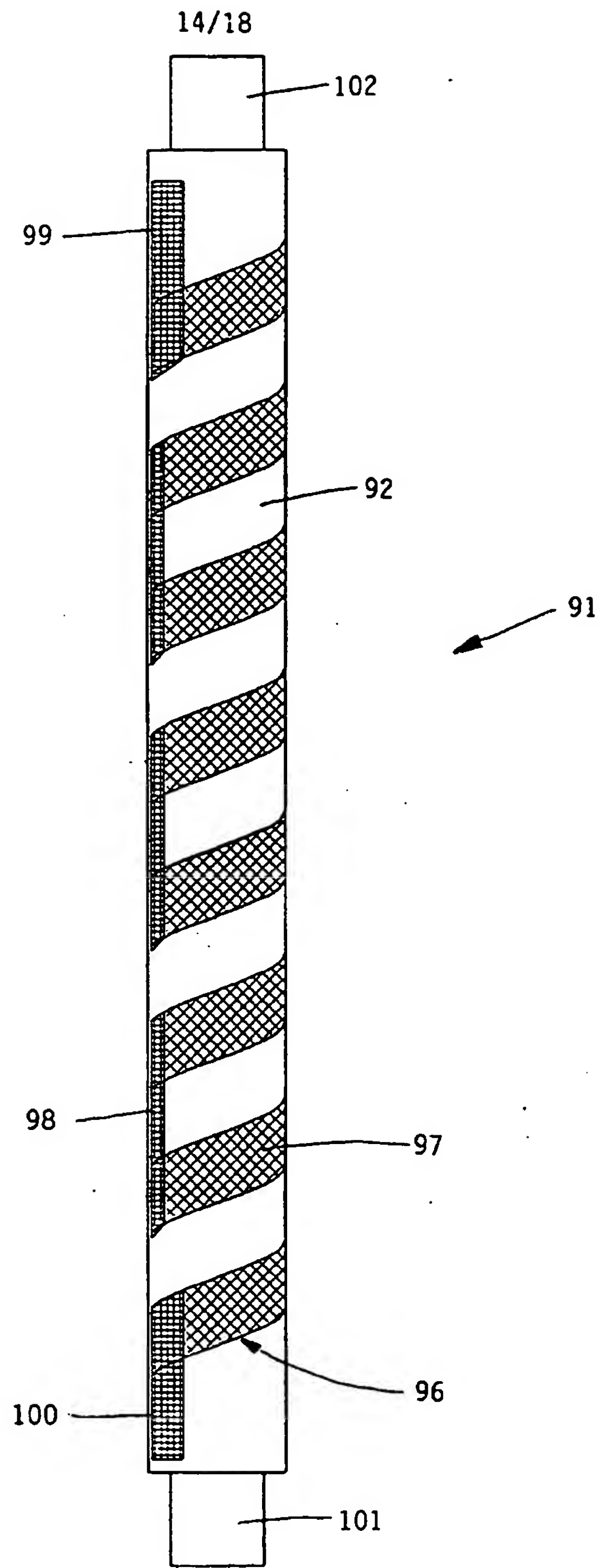


FIGURE 14.

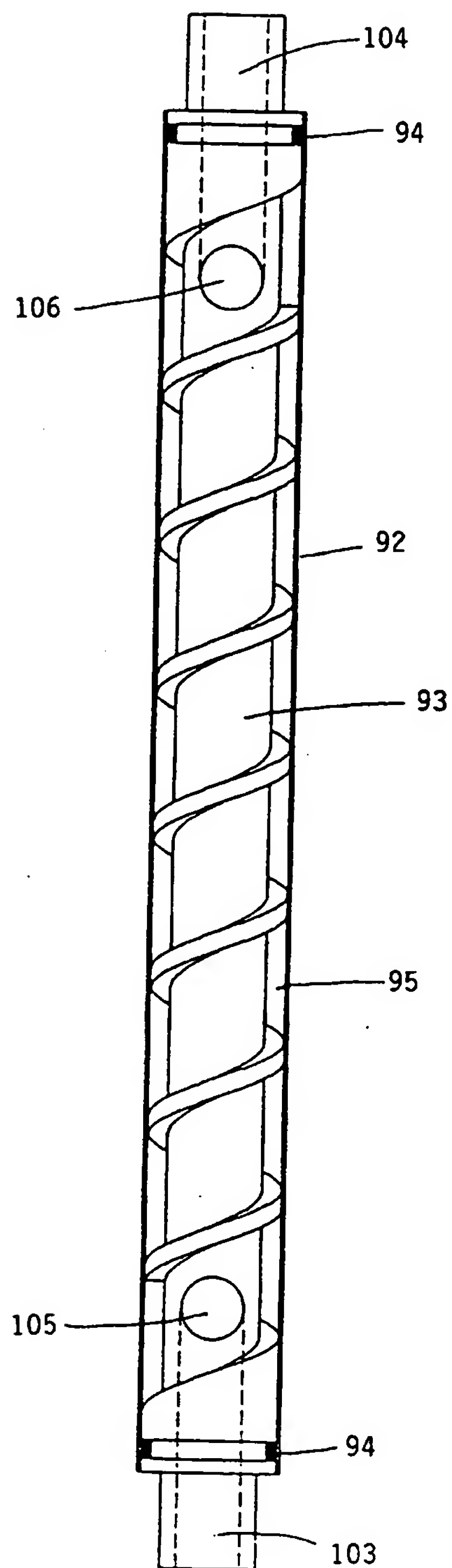


FIGURE 15.

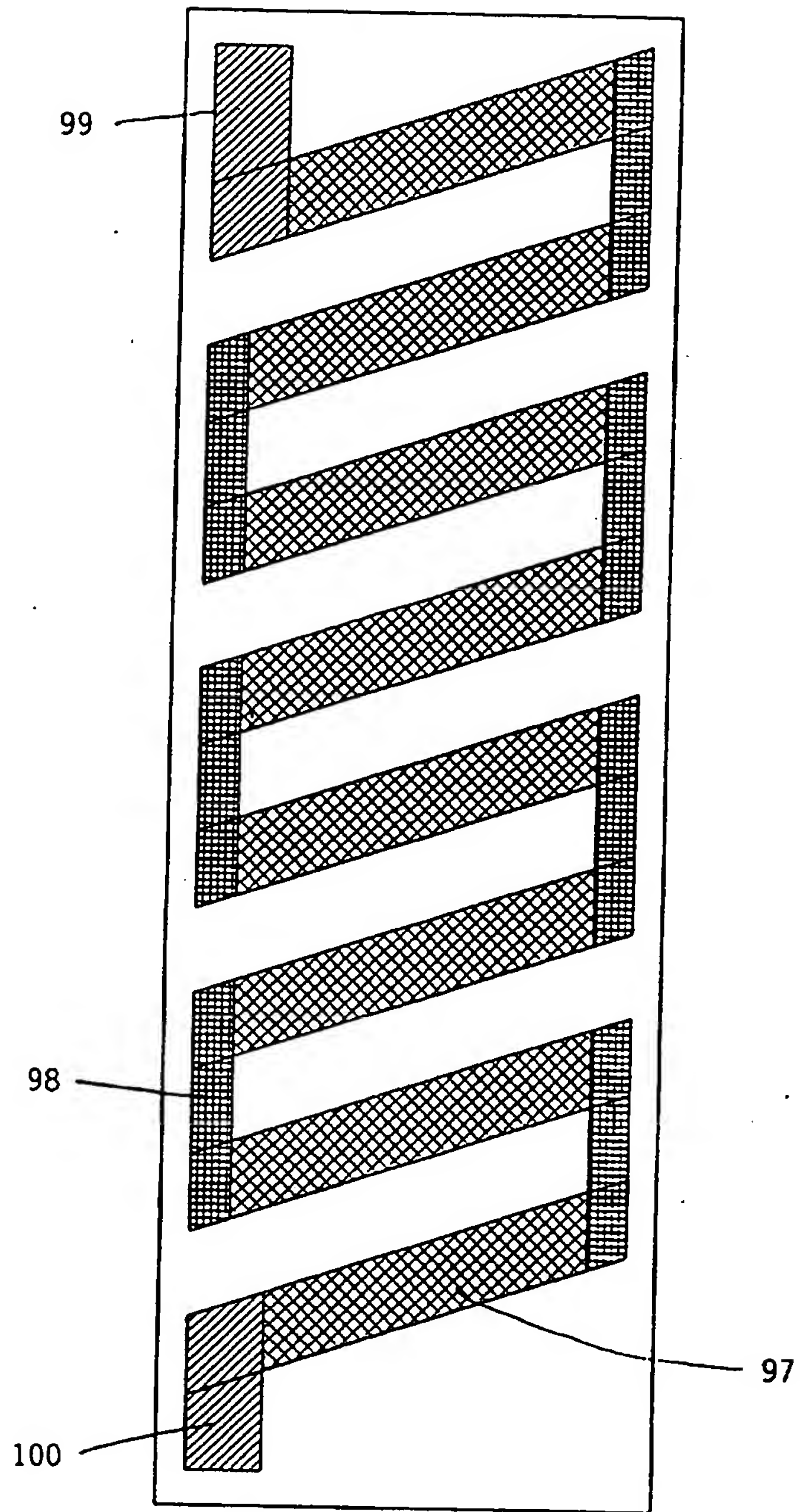


FIGURE 16.

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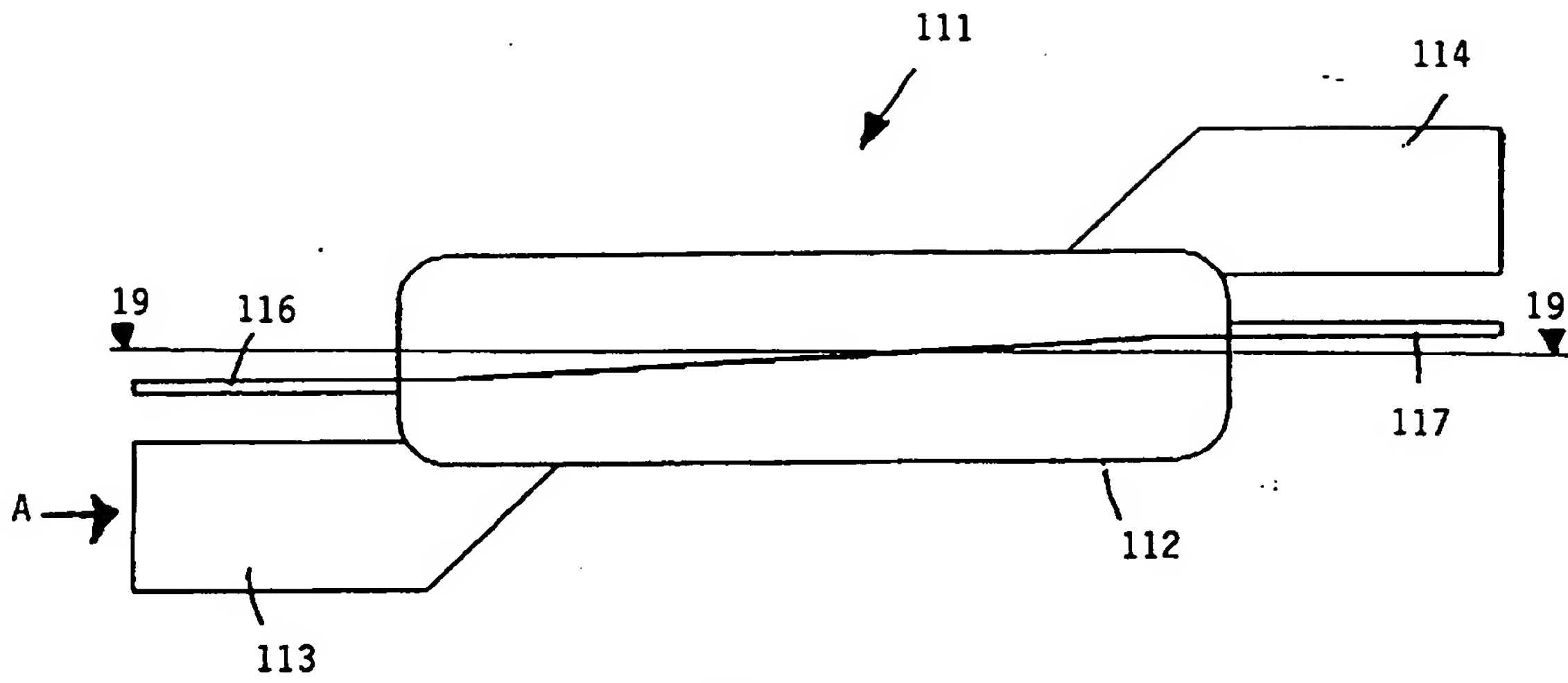


FIGURE 17.

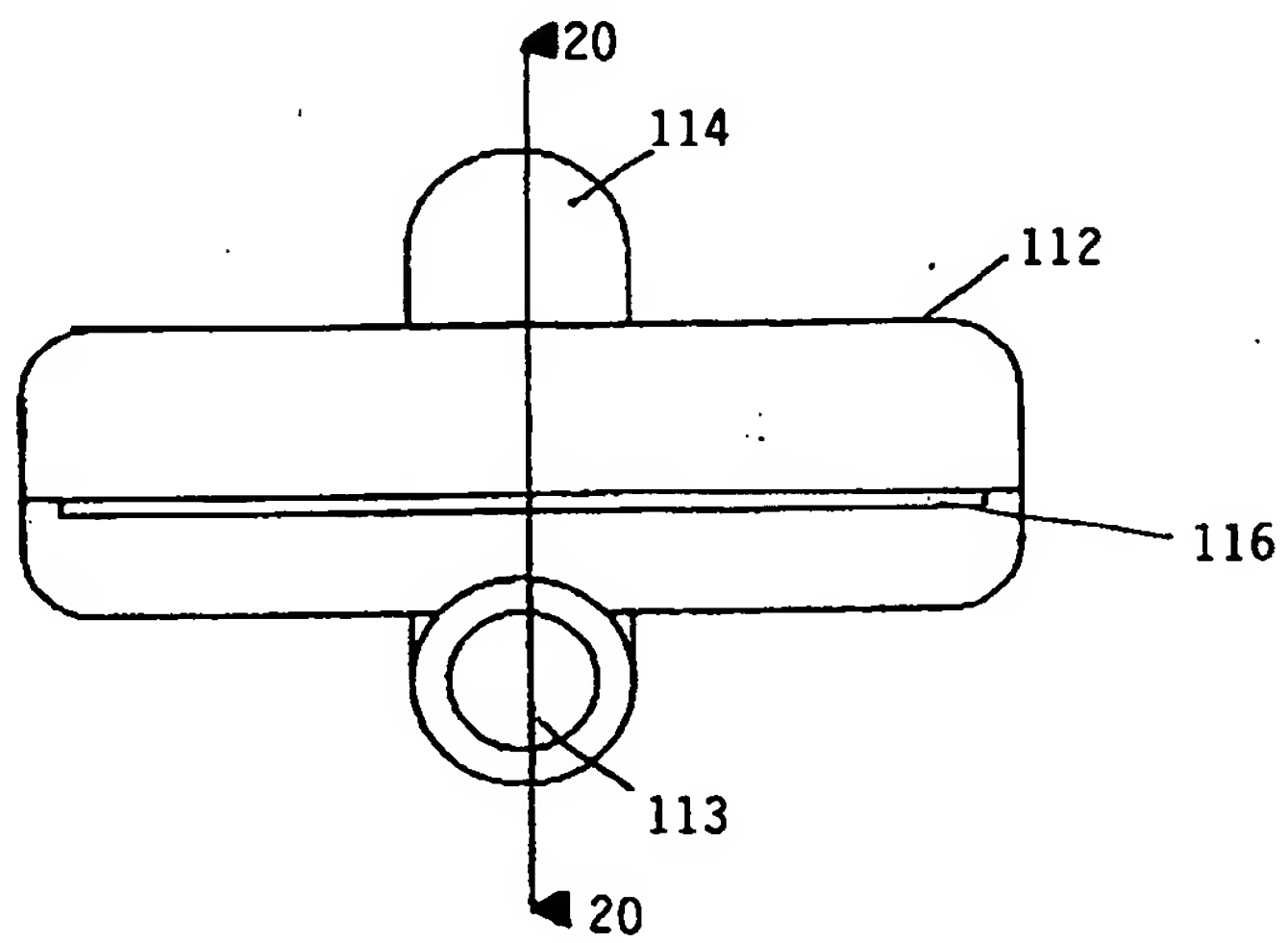


FIGURE 18.

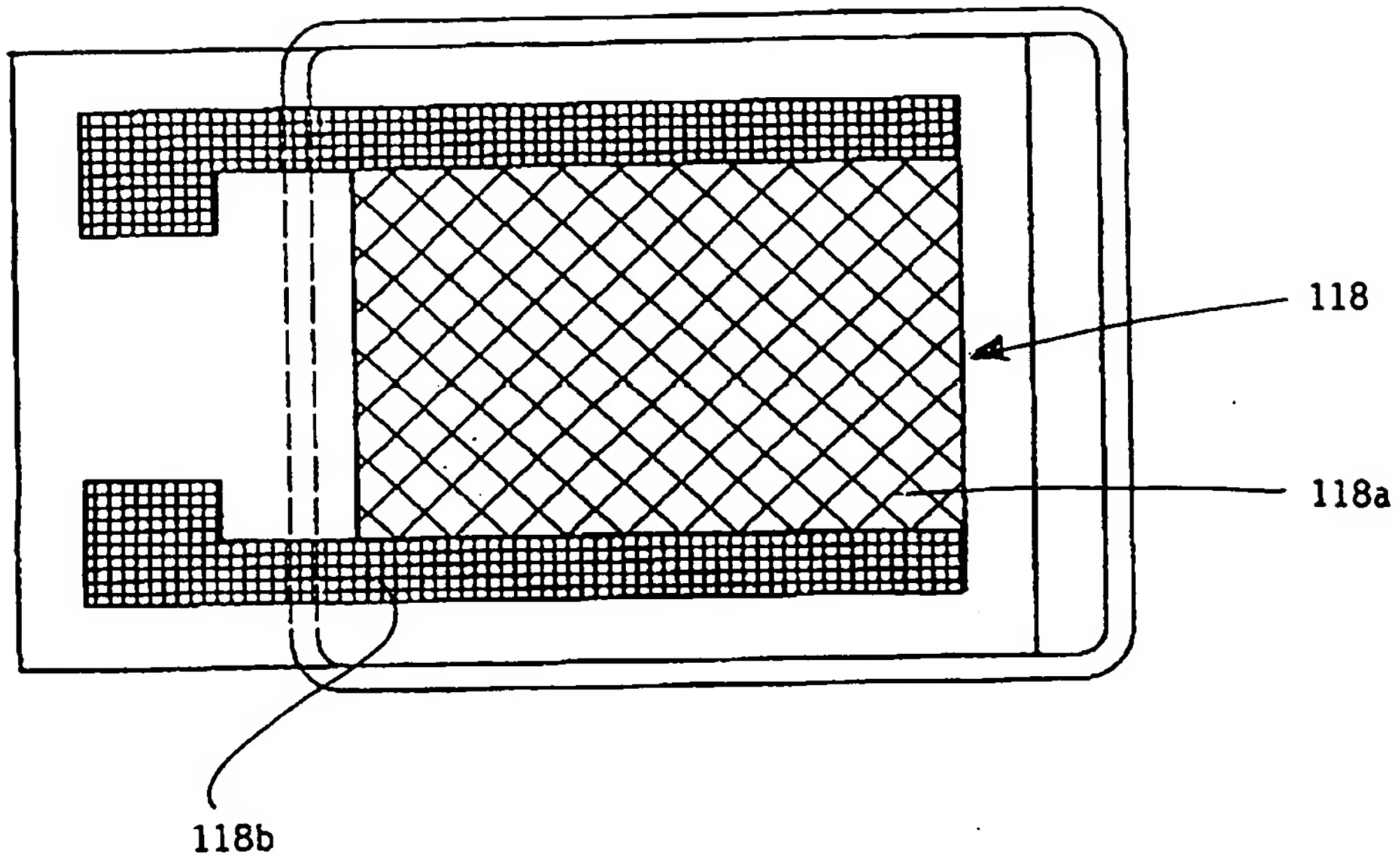


FIGURE 19.

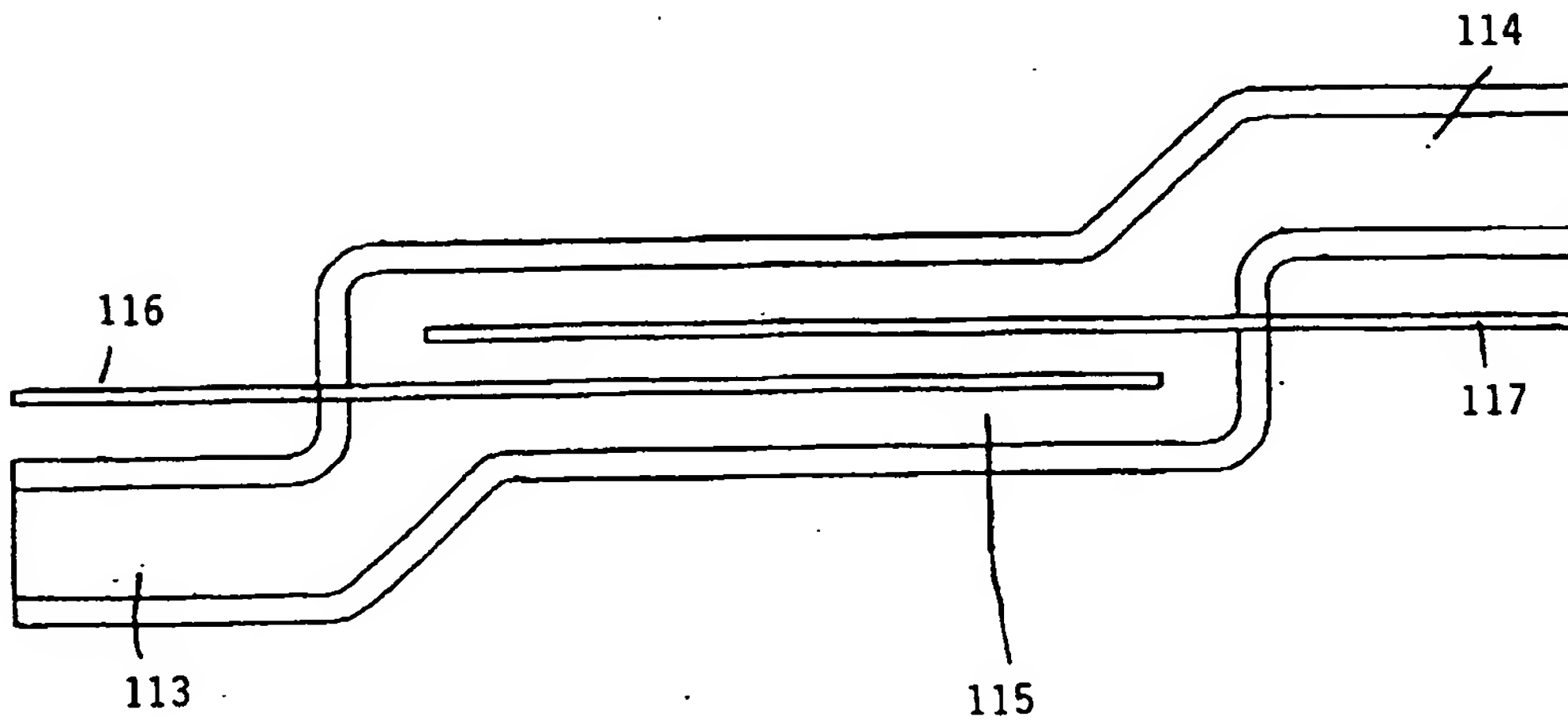


FIGURE 20

IMPROVEMENTS IN OR RELATING TO ELECTRIC WATER HEATERS

This invention concerns improvements in or relating to electric water heaters and in particular, though not exclusively, to instantaneous electric water heaters for ablutionary purposes such as showering and hand washing.

5 Known instantaneous electric water heaters provide a supply of hot water on demand by heating a stream of water flowing through the heater. The water is heated by electric heating elements contained in a heat exchanger and the water temperature is controlled by regulating the power input to the heating elements and/or the water flow through the heat
10 exchanger.

The conventional heating elements have a coiled resistance wire packed in a compressed powder inside a metal tube. The powder acts as an electrical insulator and also as a thermal insulator producing a considerable thermal inertia effect. As a result, the heat exchanger has a long time
15 constant even when the heating element is made compact by forming the tube into a coil to reduce the volume of water to be heated within the heat exchanger.

This creates a problem for accurate control of water temperature. Thus, a conventional closed loop control system has a temperature sensor in
20 the water outlet from the heat exchanger arranged to apply signals to a control mechanism for regulating the power input to and/or water flow through the heat exchanger.

In order to make the control system stable, the control mechanism is required to have considerable damping with the result that the control
25 system may be unable to respond to external changes quickly enough to keep the water temperature setting within an acceptable range.

Response may be improved by the use of a more complicated control system but the heater is still slow to settle down when starting or when the temperature setting is altered due to the thermal inertia effect of the heating
30 elements.

The conventional heating elements can give rise to other problems. Thus, the core of the element becomes so hot that the element continues to heat the water remaining in the heat exchanger for several seconds after the heater is switched off with consequential risk of scalding if the heater is
35 turned on again soon after having been switched off.

In addition, the heat energy transferred to the water can be distributed unevenly resulting in the water stream leaving the heat exchanger being made up of intermingled streams which are at different

temperatures. This causes a random variation in the outlet temperature which can be noticeable to user.

Furthermore, the water can start to boil in a region of poor water flow and high heat transfer resulting in a significant volume vibration as a steam bubble forms, moves into the water stream and condenses. This causes the water stream leaving the heat exchanger to pulsate.

These effects may be controlled by ensuring even heat transfer and good water flow but small steam bubbles can still form and collapse at surface of the heating element causing a "kettling" noise at low flow rates.

The release of air dissolved in the water coming out of solution as the water is heated can also create problems. Thus, localised overheating of the element may result where the accumulation of air bubbles preventing water flow over the surface of the element.

The known electric water heaters usually also have a thermal safety device for switching off the heating elements in response to an excessive rise in the outlet water temperature. The known devices are often slow to respond and the water temperature can rise dangerously with consequential risk of scalding before the heating elements are switched off.

The present invention has been made from a consideration of the foregoing problems and disadvantages.

According to one aspect of the present invention there is provided a heat exchanger for an electric water heater having a printed heating element.

According to another aspect of the present invention there is provided a heat exchanger for an electric water heater having a printed temperature sensor.

The invention will now be described in more detail by way of example only with reference to the accompanying drawings wherein:-

FIGURE 1 is a front view of a first embodiment of a heat exchanger according to the present invention;

FIGURE 2 is a rear view of the heat exchanger shown in Figure 1;

FIGURE 3 is a section on the line 3-3 in Figure 1;

FIGURE 4 is a front view of the separator plate shown in Figure 1;

FIGURE 5 is a schematic arrangement showing a closed loop control system using modulation of water flow to control the heat exchanger shown in Figure 1;

FIGURE 6 is a schematic arrangement showing a closed loop system using modulation of element power to control the heat exchanger shown in Figure 1.

5 **FIGURE 7** is a schematic arrangement showing a thermally responsive valve for regulating water flow to control the heat exchanger shown in Figure 1;

FIGURE 8 is a section through the valve shown in Figure 7;

FIGURE 9 is a front view of a second embodiment of a heat exchanger according to the present invention;

10 **FIGURE 10** is a section through the heat exchanger shown in Figure 9;

FIGURE 11 is a front view of a third embodiment of a heat exchanger according to the present invention;

15 **FIGURE 12** is a front view of the heat exchanger shown in Figure 11 with the element plate removed;

FIGURE 13 is a section on the line 13-13 in Figure 11;

FIGURE 14 is a side view of a fourth embodiment of a heat exchanger according to the present invention;

20 **FIGURE 15** is a side view of the heat exchanger shown in Figure 14 with the outer tube shown in section;

FIGURE 16 is a developed view of the tube shown in Figure 14;

FIGURE 17 is a side view of a fifth embodiment of a heat exchanger according to the present invention;

25 **FIGURE 18** is an end view in the direction of arrow A of the heat exchanger shown in Figure 17;

FIGURE 19 is a section on the line 19-19 of Figure 17; and

FIGURE 20 is a section on the line 20-20 of Figure 18.

Referring first to Figures 1 to 4, a heat exchanger 1 for an instantaneous electric water heater for ablutionary purposes such as
30 showering or hand washing comprises a pair of flat rectangular metal plates 2,3 secured on opposite sides of a rectangular separator plate 4 with appropriate seals (not shown) therebetween.

The plates 2,3 are secured by any suitable fasteners such as nuts and bolts. Alternatively, the plates 2,3 may be secured and sealed on opposite
35 sides of the separator plate 4 by adhesive or other bonding agents.

The separator plate 4 has a serpentine channel 5 therein and the plates 2,3 define with the channel 5 a serpentine waterway 6 having an

elongated rectangular cross-section with the plates 2,3 on the opposed long sides thereof.

Each plate 2,3 is provided on the reverse side from the waterway 6 with an integral serpentine heating element 7,8 respectively. The heating elements 7,8 are aligned with the serpentine waterway 6 and are provided at opposite ends with contact pads 9,10 respectively for connection to an electrical power source (not shown).

Each heating element 7,8 is in the form of a resistive and conductive track printed on top of one or more layers of electrically insulating material and optionally covered by one or more additional layers of electrically insulating material. The layers of electrically insulating material are typically printed but may be applied in other ways for example by spraying.

By way of non-limiting example, for a power input of 7 kilowatts, the waterway 6 can be approximately 4mm by 20mm in cross-section with heating elements 7,8 on the 20mm sides providing a heating density in the range 110-200 watts per square centimetre.

A water inlet connector 11 and a water outlet connector 12 are secured to the plate 2 on the reverse side from the waterway 6 and sealed by respective O-rings 13 (one only shown) to communicate with opposite ends of the waterway 6 through respective holes 14 (only one shown) in the plate 2.

The plate 3 has integral temperature sensors 15,16 printed opposite the holes 14 (one only shown) for sensing the inlet water temperature and the outlet water temperature. The sensors 15,16 may be applied by a separate print process to the heating element 8. The integral temperature sensors 15,16 provide rapid and accurate response to the water temperature without the cost of creating a separate sensor location or pocket.

In use, heat produced by passing an electric current through the heating elements 7,8 is conducted to water flowing through the waterway 6 by the metal plates 2,3 which provide heat exchange surfaces 17,18 on the opposed long sides of the waterway 6. As will be appreciated, the area of the heat exchange surfaces 17,18 is large and the volume of the waterway 6 is low due to the narrow elongated cross-section of the waterway 6.

As a result, heat produced by the heating elements 7,8 is conducted very quickly into water flowing through the waterway 6 producing a fast speed of response and heats all the water in the cross-section reducing random variations in the outlet water temperature. The speed of response is

further improved by the small mass of the printed heating elements 7,8 and the short conductive path to the water.

It will also be appreciated that as well as improving the speed of response, the compact cross-section of the waterway 6 ensures good water flow preventing formation of stagnant water areas so that localised boiling and undesirable pulsation effects are avoided. In addition, the water velocities at the heat exchange surfaces are sufficient to prevent formation of steam bubbles even with low water flows so that undesirable kettling noises are avoided.

Furthermore, the water flow through the heat exchanger 1 rises from the inlet to the outlet so that any dissolved air released from the water as it is heated is immediately flushed out preventing formation of air pockets affecting heat transfer and avoiding localised overheating of the elements 7,8.

The improvement in the speed of response enables the use of closed loop control systems which are effective in maintaining accurate temperature control for ablutionary purposes as now described with reference to Figures 5 to 8.

Figure 5 shows a closed loop control system 20 for regulating the water flow comprising an electronic control unit 21 arranged to receive an input signal from a user operable control 22 for adjustable selection of the desired outlet water temperature and a feedback signal from the outlet water temperature sensor 16 of the actual outlet water temperature.

The control unit 21 compares the input signal and the feedback signal and generates a control signal for operating a flow modulating valve 23 controlling the water flow to the heat exchanger 1 to adjust the water flow to obtain and maintain substantially constant the desired water temperature.

The outlet water temperature does not change linearly as the water flow is changed and, to compensate for this, the inlet water temperature sensor 15 can be used to provide an additional input signal to the electronic control unit 21 from which the water flow rate can be deduced and the system gain adjusted accordingly to optimise the temperature control.

Figure 6 shows an alternative closed loop control system 30 for regulating the power input comprising an electronic control unit 31 arranged to receive an input signal from a user operable control 32 for adjustable selection of the desired outlet water temperature and a feedback signal from the outlet water temperature sensor 16 of the actual outlet water temperature.

The water flow is controlled by a valve 33 set either manually or by the control unit 31, and the control unit 31 compares the input signal and feedback signals and generates a control signal for regulating the power supply either to switch various sections of the heating elements 7,8 on or off and/or by having a proportion of the heating elements 7,8 to which the power is modulated to obtain and maintain substantially constant the desired water temperature. The outlet water temperature changes linearly as the power input is changed so that an additional input signal from the inlet water temperature sensor 15 may not be required and this sensor may be omitted.

Figures 7 and 8 show another control system 40 for regulating the water flow comprising a thermally responsive valve 41 having separate waterways 42 and 43 connected to the water inlet connector 11 and water outlet connector 12 respectively of the heat exchanger 1.

A valve member 44 in the inlet waterway 42 for controlling water flow is coupled via a thermal actuator 45 in the outlet waterway 43 to a user operable control spindle 46 for adjustable selection of the desired water temperature.

The valve member 44 has axial grooves 47 co-operable with an O-ring 48 which is deformable to compensate automatically for changes in water pressure to vary the cross-section of the grooves 47 to maintain constant a selected flow rate.

The thermal actuator 45 is responsive to the actual outlet water temperature to adjust the valve member 44 from the position set by the control spindle 46 to maintain constant the desired outlet water temperature. Positioning the thermal actuator 45 close to the outlet from the heat exchanger 1 reduces transport delays.

The valve member 44 compensates for changes in the water pressure and the thermal actuator 45 responds to changes in the outlet water temperature enabling the valve to have a consistent gain characteristic irrespective of water pressure and the rate of change of flow can also be characterised to give a linear response in respect to outlet water temperature.

The above-described control systems may include a safety control circuit arranged to switch off the power when a pre-set outlet water temperature is detected to protect the user being scalded in the event of malfunction. For this the printed outlet water temperature sensor can be positioned close to the printed resistive and conductive tracks used for heating the water enabling the sensor to detect and respond to rapidly rising

water temperature more quickly than conventional thermal switches and sensors used with conventional heating elements. As a result, it may not be necessary to stop the water flow when switching off the power to prevent over hot water escaping.

5 The advantages of the invention are not limited to the heat exchanger above-described and other constructions are possible as will be apparent from the following description with reference to Figures 9 to 20.

10 Figures 9 and 10 show a heat exchanger 51 comprising two rectangular metal plates 52,53 welded, bolted or bonded together to define a serpentine waterway 54 of elongate rectangular cross-section between
10 respective serpentine channels 55,56 pressed in the plates. This construction is capable of withstanding higher internal pressures than the construction shown in Figures 1 to 4.

15 The base of each channel 55,56 is flat and has a heating element 57 (one only shown) on the reverse side from the waterway 54. The heating elements 57 follow a serpentine path corresponding to the waterway 54 and are in the form of resistive and conductive tracks printed on top of one or more layers of electrically insulating material and optionally covered by one or more layers of electrically insulating material as previously described.

20 Each heating element 57 has electrical contact pads 58,59 respectively at the ends for connecting the elements 57 to an electrical power source. In this way, the heat produced when an electric current is passed through the elements 57 is conducted by the plates 52,53 into water flowing through the heat exchanger 51 at heat exchange surfaces 60,61 on
25 the opposed long sides of the waterway 54.

30 The waterway 54 communicates at opposite ends with a water inlet connector (not shown) and a water outlet connector (not shown) through respective holes 62,63 in the plate 52 and the plate 53 has temperature sensors (not shown) printed opposite the holes 62,63 for sensing the water inlet temperature and water outlet temperature respectively.

35 Figures 11 to 13 show a heat exchanger 71 comprising a rectangular panel 72 with a serpentine channel 73 on one side and a flat rectangular metal plate 74 secured to the panel 72 by screws 75 and sealed by a gasket 76 to define with the channel 73 a serpentine waterway 77 having an elongate rectangular cross-section. Alternatively, the plate 74 may be bonded to the panel 72.

 The plate 74 has two heating elements 78,79 arranged in series on the reverse side from the waterway 77. The heating elements 78,79 follow a

serpentine path corresponding to the waterway 77 and are in the form of resistive and conductive tracks printed on top of one or more layers of electrically insulating material and optionally covered by one or more layers of electrically insulating material as previously described.

5 Each heating element 78,79 has electrical contact pads 80,81 respectively at the ends for connecting the elements 78,79 to an electrical power source. In this way, the heat produced by passing an electric current through one or both elements 78,79 is conducted by the plate 74 into water flowing through the heat exchanger 71 at respective heat exchange
10 surfaces 82,83 on one long side of the waterway 77.

 The panel 72 has a water inlet connector 84 and a water outlet connector 85 integrally formed on the reverse side from the waterway 77 and is reinforced by a series of spaced parallel reinforcing ribs 86 integrally formed between the inlet connector 84 and outlet
15 connector 85.

 The inlet connector 84 and outlet connector 85 communicate with opposite ends of the waterway 77 through holes 87 and 88 respectively in the panel 72, and the plate 74 has temperature sensors (not shown) printed opposite the holes 87,88 for sensing the water inlet temperature and the
20 water outlet temperature respectively.

 Figures 14 to 16 show a heat exchanger 91 comprising a cylindrical metal tube 92 and an insert 93 sealed at opposite ends of the tube 92 by respective O-rings 94 to define a helical waterway 65 within the tube 92. Alternatively, the insert 93 may define a serpentine waterway within the
25 tube 92.

 The tube 92 has a heating element 96 on the outside in the form of a resistive and conductive track printed on top of one or more layers of electrically insulating material and optionally covered by one or more layers of electrically insulating material as previously described. The track is
30 arranged in sections 97 corresponding to the waterway 95 with links 98 connecting the sections 97.

 The heating element 96 has contacts pads 99,100 at the ends for connecting the element 96 to an electrical power supply so that, when an electric current is passed through the element 96, the heat produced is
35 conducted by the tube 92 into the water flowing through the heat exchanger 91. The heating element 96 may be applied to the tube 92 using printed transfers.

The insert 93 has a water inlet connector 101 at one end and a water outlet connector 102 at the other end with axial bores 103 and 104 respectively that communicate with opposite ends of the waterway 95 through radial holes 105 and 106 respectively, and the tube 92 has
5 temperature sensors (not shown) printed opposite the holes 105,106 for sensing the inlet water temperature and the outlet water temperature.

Figures 17 to 20 show a heat exchanger 111 comprising a rectangular metal tank 112 with an inlet 113 at one end and an outlet 114 at the other end offset on opposite sides of the tank 112. The tank 112 has a serpentine
10 waterway 115 between the inlet 113 and the outlet 114 formed by two flat plates 116,117 arranged in spaced parallel relationship. The tank 112 is formed in two halves joined together with the plates 116,117 and sealed in any suitable manner.

The plates 116,117 project from the tank 112 at opposite ends and are
15 provided on each side with a heating element 118 comprising resistive and conductive tracks 118a, 118b printed on one or more layers of electrically insulating material. The conductive tracks are exposed on the outside of the tank 112 for making the appropriate electrical connections to the heating elements 118.

20 Within the tank 112, the resistive and conductive tracks are covered by one or more layers of electrically insulating material to isolate the heating elements 118 from the water flowing through the tank 112 and the insulating layer(s) are covered by one or more layers of electrically conducting material for making an earth connection to meet safety
25 requirements.

As will be understood, by employing flat plates 116,117 with heating elements 118 on both sides, the rate at which heat is dissipated to water flowing through the tank is at least doubled reducing the overall size of the printed heating elements required thereby reducing cost.

30 Furthermore, the plates 116,117 are not subject to the stresses caused by the water pressure in the tank 112 enabling the plates 116,117 to be made of metal or other suitable materials such as ceramic. In addition, manufacture of the heating elements 118 by printing on flat plates is simplified.

35 More than one resistive track may be printed on the elements 118 so that alternative power inputs can be switched by any suitable means. Temperature sensors (not shown) may be printed on the plates 116,117

adjacent to the inlet 113 and outlet 114 for monitoring the water inlet and outlet temperatures.

Furthermore, the number and arrangement of plates 116,117 within the tank 112 can be varied from that shown. Also, the orientation and
5 arrangement of the inlet 113 and outlet 114 is desirably chosen so that any air which comes out of solution as the water is heated is flushed through the tank 112.

The heat exchangers shown in Figures 9 to 20 can be used in instantaneous electric water heaters for ablutionary purposes using any of
10 the previously described control systems shown in Figures 5 to 8 to obtain and maintain substantially constant a desired water temperature.

It will be understood that the above-described embodiments are provided by way of example only of possible constructions of heat exchangers using heating elements in the form of printed resistive and
15 conductive tracks to heat water as it flows through the heat exchanger and that various modifications can be made.

For example, one or more resistive and conductive tracks can be provided internally or externally of the waterway with appropriate electrical contacts. Suitable materials for the resistive tracks include metal oxides and
20 suitable materials for the conductive tracks include silver and palladium.

Where more than one track is provided, the tracks can be arranged along the waterway in parallel or in series. The inlet and outlet temperature sensors may be printed as described or any other type of temperature sensor may be used to monitor the water temperature.

25 Other safety features may be provided such as a pressure relief valve to prevent an excessive build-up of pressure in the heat exchanger or a flow sensor to prevent the power being switched on if there is insufficient water flow through the heat exchanger.

Claims:

1. An instantaneous electric water heater comprising a heat exchanger having a printed heating element.
2. An instantaneous electric water heater according to Claim 1 wherein
5 the heat exchanger has a water inlet and a water outlet at opposite ends of an elongate waterway and the heating element is arranged to heat water flowing through the waterway.
3. An instantaneous electric water heater according to Claim 2 wherein
10 the heating element comprises a resistive and conductive track printed over a thermally conductive surface of the waterway for conducting heat produced by passing an electric current through the heating element to water flowing through the waterway.
4. An instantaneous electric water heater according to Claim 2 or
15 Claim 3 wherein the waterway and heating element are aligned along a serpentine path rising from the inlet to the outlet.
5. An instantaneous electric water heater according to Claim 4 wherein the waterway is of elongate rectangular cross-section with the heating element on one long side.
6. An instantaneous electric water heater according to Claim 5 wherein a
20 second printed heating element is provided on the opposed long side of the waterway.
7. An instantaneous electric water heater according to Claim 5 or Claim 6 wherein a plurality of printed heating elements are provided in series or in parallel on one or both long sides of the waterway.
- 25 8. An instantaneous electric water heater according to Claim 2 or Claim 3 wherein the waterway and heating element are aligned along a helical path rising from the inlet to the outlet.
9. An instantaneous electric water heater according to Claim 8 wherein a plurality of printed heating elements are provided in series or parallel along
30 the helical path.
10. An instantaneous electric water heater according to any one of Claims 3 to 9 wherein the thermally conductive surface is made of metal and the or each heating element is printed on top of electrically insulating material on the outside of the waterway.
- 35 11. An instantaneous electric water heater according to any one of the preceding Claims including a closed loop control system operable to regulate power input to the heat exchanger in response to the outlet water temperature to maintain substantially constant a selected water temperature.

12. An instantaneous electric water heater according to any one of Claims 1 to 10 including a closed loop control system operable to regulate water flow through the heat exchanger in response to the outlet water temperature to maintain substantially constant a selected water temperature.
- 5 13. An instantaneous electric water heater according to Claim 11 or Claim 12 including a printed temperature sensor for monitoring the outlet water temperature.
14. An instantaneous electric water heater according to any one of Claims 1 to 10 including a closed loop control system operable to regulate
10 water flow through the heat exchanger in response to the inlet water temperature and the outlet water temperature to maintain substantially constant a selected water temperature.
15. An instantaneous electric water heater according to Claim 14 including printed temperature sensors for monitoring the inlet water
15 temperature and the outlet water temperature.
16. An instantaneous electric water heater according to any one of Claims 1 to 10 including a valve for controlling water flow and a thermal actuator responsive to outlet water temperature for adjusting the valve to regulate the water flow to maintain substantially constant a selected water
20 temperature.
17. An instantaneous electric water heater comprising at least one heating element formed by a printed circuit including a resistive track.
18. An instantaneous electric water heater comprising at least one heating element formed by a printed circuit including a conductive track.
- 25 19. An instantaneous electric water heater substantially as hereinbefore described with reference to Figures 1,2,3 and 4 of the accompanying drawings.
20. An instantaneous electric water heater substantially as hereinbefore described with reference to Figures 9 and 10 of the accompanying drawings.
- 30 21. An instantaneous electric water heater substantially as hereinbefore described with reference to Figures 11,12 and 13 of the accompanying drawings.
22. An instantaneous electric water heater substantially as hereinbefore described with reference to Figures 14,15 and 16 of the accompanying
35 drawings.
23. An instantaneous electric water heater substantially as hereinbefore described with reference to Figures 17,18,19 and 20 of the accompanying drawings.

24. An instantaneous electric water heater according to any one of Claims 19 to 23 substantially as hereinbefore described with reference to Figure 5 or Figure 6 or Figures 7 and 8 of the accompanying drawings.
25. An ablutionary installation for showering, hand washing or the like
- 5 comprising an instantaneous electric water heater according to any one of the preceding Claims.
26. An instantaneous electric water heater comprising the steps, features or integers substantially as hereinbefore described and/or as shown in the accompanying drawings either individually or in any combination.



Application No: GB 9806970.1
Claims searched: 1-26

Examiner: Peter Emerson
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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): F4A ADD, AHA, AJH; H5H HBG1, HBG2, HBG3

Int Cl (Ed.6): H05B 3/26, 3/30, 3/82; F24H 1/10, 1/12, 1/14, 1/16

Other: OPTICS: H5H [H109 + (H243/S1976)]

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X, E	GB 2305233 A (WELWYN) - whole doc relevant.	1-4, 10-14, 16-18
X	GB 2109516 A (OVERSEAS) - whole doc - esp fig3.	1-3, 8, 9, 11, 17, 18
X	EP 0485211 A1 (IST) - whole doc, figs 1, 5, 9.	1-5, 8, 10, 11, 17, 18

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.